CLAIMS

1. An antenna apparatus comprising:

a plurality of antenna units for respectively transmitting and receiving a radio signal using a main beam of a sector pattern thereof;

at least one load impedance element; and

control means for controlling the antenna apparatus so that the antenna unit that transmits and receives the radio signal of the plurality of antenna units is connected to a radio communication apparatus circuit and the other antenna units are connected to the load impedance element.

2. The antenna apparatus as claimed in Claim 1,

wherein the plurality of antenna units is arranged so that directions of the main beams of the respective antenna units are different to each other.

3. The antenna apparatus as claimed in Claim 1,

wherein the plurality of antenna units is arranged so that directions of the main beams of the respective antenna units are orthogonal to each other.

4. The antenna apparatus as claimed in any one of Claims 1 to 3,

wherein the control means controls the antenna apparatus so that the antenna unit that receives the radio signal having the maximum signal level among the radio signals received by the respective antenna units is connected to the radio communication apparatus circuit.

5. The antenna apparatus as claimed in any one of Claims 1 to 4,

wherein the plurality of antenna units is respectively formed by waveguide array antenna apparatus comprising a plurality of waveguide antenna units provided on a ground conductor, each of waveguide antenna units including a rectangular waveguide and an antenna element,

wherein each of the rectangular waveguides comprises the ground conductor, a ceiling conductor facing the ground conductor, and two side

conductors that connect the ground conductor with the ceiling conductor and face each other, and has one end short-circuited by a terminating conductor and an open end, the open ends of the respective rectangular waveguides are arranged on corresponding sides of a polygon on the ground conductor having sides of the same number as that of the rectangular waveguides, and the rectangular waveguides extend outward from the corresponding sides of the polygon on the ground conductor,

wherein one ends of the respective antenna elements are electrically connected to the ceiling conductors in vicinity of the open ends of the respective rectangular waveguides, and another ends thereof are electrically connected to each of a plurality of feeding points arranged on the ground conductor, and

wherein the waveguide antenna units respectively transmit and receive the radio signal using a predetermined directivity characteristic at the open ends of the rectangular waveguides constituting the waveguide antenna units.

6. The antenna apparatus as claimed in Claim 5,

wherein the plurality of waveguide antenna units has substantially the same structure as each other, the open ends of the respective rectangular waveguides are arranged on corresponding sides of a regular polygon on the ground conductor having sides of the same number as that of the rectangular waveguides, and the respective rectangular waveguides extend outward from the corresponding sides of the regular polygon on the ground conductor.

7. The antenna apparatus as claimed in any one of Claims 1 to 4,

wherein the plurality of antenna units is respectively formed by a waveguide array antenna apparatus comprising a plurality of waveguide antenna units provided on a ground conductor, each of the waveguide antenna units including a rectangular waveguide and an antenna element,

wherein each of the rectangular waveguides comprises the ground conductor, a ceiling conductor facing the ground conductor, and two side conductors that connect the ground conductor with the ceiling conductor and face each other, and has one end short-circuited by a terminating conductor and an open end, the open ends of the respective rectangular waveguides are arranged on corresponding sides of a polygon on the ground conductor having sides of the same number as that of the rectangular waveguides, the rectangular waveguides extend outward from the corresponding sides of the polygon on the ground conductor, and at least one of the rectangular waveguides comprises at least one slot formed in the ceiling conductor in a width direction of the rectangular waveguide,

wherein one ends of the respective antenna elements are electrically connected to the ceiling conductors in vicinity of the open ends of the respective rectangular waveguides, and another ends thereof are electrically connected to each of a plurality of feeding points arranged on the ground conductor, and

wherein the waveguide antenna units respectively transmit and receive the radio signal using a predetermined directivity characteristic at the open ends of the rectangular waveguides constituting the waveguide antenna units.

8. The antenna apparatus as claimed in Claim 7,

wherein the waveguide array antenna apparatus comprises slots of the same number as an integral multiple of number of the feeding points, the slots are provided in each of the ceiling conductors constituting the waveguide antenna units of the same number as that of the feeding points, the numbers of the slots provided on the respective ceiling conductors are equal to each other, the plurality of the waveguide antenna units has the same structure as each other, the open ends of the rectangular waveguides are arranged on corresponding sides of a regular polygon on the ground

conductor having sides of the same number as that of the rectangular waveguides, and the respective rectangular waveguides extend outward from the corresponding sides of the regular polygon on the ground conductor.

9. The antenna apparatus as claimed in Claim 7 or 8,

wherein the slots are respectively formed at positions between connecting points with the antenna elements of the ceiling conductors, and the terminating conductors.

10. The antenna apparatus as claimed in any one of Claims 5 to 9,

wherein at least one part of an internal space in each of the rectangular waveguides is filled with a dielectric material.

11. The antenna apparatus as claimed in Claim 10,

wherein the ground conductor is made of an electrical conductor pattern formed on a first surface of a dielectric substrate having first and second surfaces opposing to each other,

wherein the respective ceiling conductors are made of an electrical conductor pattern formed on the second surface of the dielectric substrate, and

wherein the side conductors and the terminating conductors are respectively formed by a plurality of through-hole conductors formed by filling through holes formed in the dielectric substrate in a thickness direction thereof with conductors.

12. The antenna apparatus as claimed in any one of Claims 1 to 4,

wherein the plurality of antenna units is respectively formed by a waveguide array antenna apparatus comprising a plurality of waveguide antenna units provided on a ground conductor, each of the waveguide antenna units including a rectangular waveguide and an antenna element,

wherein each of the rectangular waveguides comprises the ground conductor, a ceiling conductor facing the ground conductor, and two partitioning-wall conductors that connect the ground conductor with the

ceiling conductor and face each other, the rectangular waveguides are arranged in such manner that the partitioning-wall conductors are respectively shared between the two rectangular waveguides adjacent to each other, each of the rectangular waveguides comprises one end short-circuited by a terminating conductor and an open end, the open ends of the respective rectangular waveguides are arranged on corresponding sides of a polygon on the ground conductor having sides of the same number as that of the rectangular waveguides, and the rectangular waveguides extend outward from the corresponding sides of the polygon on the ground conductor,

wherein one ends of the respective antenna elements are electrically connected to the ceiling conductors in vicinity of the open ends of the respective rectangular waveguides, and another ends thereof are electrically connected to each of a plurality of feeding points arranged on the ground conductor, and

wherein the waveguide antenna units respectively transmit and receive the radio signal using a predetermined directivity characteristic at the open ends of the rectangular waveguides constituting the waveguide antenna units.

13. The antenna apparatus as claimed in Claim 12,

wherein the plurality of waveguide antenna units has the same structure as each other, the open ends of the respective rectangular waveguides are arranged on corresponding sides of a regular polygon on the ground conductor having sides of the same number as that of the rectangular waveguides, and the respective rectangular waveguides extend outward from the corresponding sides of the regular polygon on the ground conductor.

14. The antenna apparatus as claimed in any one of Claims 1 to 4, wherein the plurality of antenna units is respectively formed by a

waveguide array antenna apparatus comprising a plurality of waveguide antenna units provided on a ground conductor, each of the waveguide antenna units including a rectangular waveguide and an antenna element,

wherein each of the rectangular waveguides comprises the ground conductor, a ceiling conductor facing the ground conductor, and two partitioning-wall conductors that connect the ground conductor with the ceiling conductor and face each other, the rectangular waveguides are arranged in such manner that the partitioning-wall conductors are respectively shared between the two rectangular waveguides adjacent to each other, each of the rectangular waveguides has one end short-circuited by a terminating conductor and an open end, the open ends of the respective rectangular waveguides are arranged on corresponding sides of a polygon on the ground conductor having sides of the same number as that of the rectangular waveguides, the rectangular waveguides extend outward from the corresponding sides of the polygon on the ground conductor, and at least one of the rectangular waveguides comprises at least one slot formed in the ceiling conductor in a width direction of the rectangular waveguide,

wherein one ends of the respective antenna elements are electrically connected to the ceiling conductors in vicinity of the open ends of the respective rectangular waveguides, and another ends thereof are electrically connected to each of a plurality of feeding points arranged on the ground conductor, and

wherein the waveguide antenna units respectively transmit and receive the radio signal using a predetermined directivity characteristic at the open ends of the rectangular waveguides constituting the waveguide antenna units.

15. The antenna apparatus as claimed in Claim 14,

wherein the waveguide array antenna apparatus comprises slots of the same number as an integral multiple of number of the feeding points,

slots are provided in the ceiling conductors constituting the waveguide antenna units of the same number as that of the feeding points, the numbers of the slots provided in respective ceiling conductors are equal to each other, the plurality of the waveguide antenna units has the same structure as each other, the open ends of the rectangular waveguides are arranged on corresponding sides of a regular polygon on the ground conductor having sides of the same number as that of the rectangular waveguides, and the respective rectangular waveguides extend outward from the corresponding sides of the regular polygon on the ground conductor.

16. The antenna apparatus as claimed in Claim 14 or 15,

wherein the slots are respectively formed at positions between connecting points with the antenna elements of the ceiling conductors, and the terminating conductors.

17. The antenna apparatus as claimed in any one of Claims 12 to 16,

wherein at least one part of an internal space in each of the rectangular waveguides is filled with a dielectric material.

18. The antenna apparatus as claimed in Claim 17,

wherein the ground conductor is made of an electrical conductor pattern formed on a first surface of a dielectric substrate having first and second surfaces opposing to each other,

wherein the ceiling conductors are each made of an electrical conductor pattern formed on the second surface of the dielectric substrate, and

wherein the partitioning-wall conductors and the terminating conductors are respectively formed by a plurality of through-hole conductors formed by filling through holes formed in the dielectric substrate in a thickness direction thereof with conductors.

19. The antenna apparatus as claimed in any one of Claims 1 to 18,

further comprising a matching conductor connected between each of the ceiling conductors and the ground conductor in vicinity of the antenna elements of the antenna units, the matching conductor adjusting input impedances of the respective antenna elements.

20. The antenna apparatus as claimed in any one of Claims 1 to 18, further comprising at least one matching conductor electrically connected to the ground conductor of the antenna units, the matching conductor adjusting an input impedance of the respective antenna apparatus.

21. The antenna apparatus as claimed in Claim 20,

wherein at least one of the antenna elements is electrically connected to at least one of the matching conductors.

22. The antenna apparatus as claimed in Claim 20,

wherein at least one of the ceiling conductors is electrically connected to at least one of the matching conductors.

23. The antenna apparatus as claimed in any one of Claims 1 to 22, further comprising at least one directivity characteristic controlling conductor electrically connected to the ground conductor of the respective antenna units, the directivity characteristic controlling conductor changing a directivity characteristic of the antenna apparatus.

24. The antenna apparatus as claimed in Claim 23,

wherein the directivity characteristic controlling conductor comprises:

a first electrical conductor part electrically connected to the ground conductor and provided to be substantially vertical to the ground conductor, the first electrical conductor part controlling a directivity characteristic on a plane substantially vertical to the ground conductor; and

a second electrical conductor part connected to the first electrical conductor part and provided to be substantially in parallel to the ground conductor, the second electrical conductor part controlling a directivity

characteristic on a plane substantially in parallel to the ground conductor.

25. The antenna apparatus as claimed in Claim 24,

wherein the second electrical conductor part of the directivity characteristic controlling conductor is connected to the first electrical conductor part of the directivity characteristic controlling conductor at a central part in a longitudinal direction of the second electrical conductor part, and

wherein a sum of a length of the first electrical conductor part and half a length of the second electrical conductor part is substantially a quarter of a wavelength corresponding to a resonance frequency of the waveguide antenna unit whose directivity characteristic is controlled by the directivity characteristic controlling conductor.

26. The antenna apparatus as claimed in any one of Claims 1 to 25,

wherein the control means comprises:

a plurality of first switch means provided to respectively correspond to the respective antenna units; and

second switch means connected to the first switch means, and

wherein each of the first switch means selectively connects the respective antenna units to one of the second switch means and the load impedance element,

wherein the second switch means selectively connects one of the plurality of first switch means to the radio communication apparatus circuit, and

wherein the control means controls the plurality of first switch means and the second switch means, so that, among the plurality of antenna units, the antenna unit that transmits and receives the radio signal is connected to the radio communication apparatus circuit, and the other antenna units are connected to the load impedance element.

27. The antenna apparatus as claimed in any one of Claims 1 to 25,

wherein the control means comprises:

a plurality of first switch means provided to respectively correspond to the respective antenna units; and

a signal combiner and distributor means connected to the first switch means, and

wherein each of the first switch means selectively connects the antenna units to one of the signal combiner and distributor means and the load impedance element,

wherein the signal combiner and distributor means combine the respective radio signals outputted from the plurality of first switch means, and outputs a combined signal to the radio communication apparatus circuit, and

wherein the control means controls the plurality of first switch means, so that, among the plurality of antenna units, the antenna unit that transmits and receives the radio signal is connected to the radio communication apparatus circuit, and the other antenna units are connected to the load impedance element.

28. The antenna apparatus as claimed in any one of Claims 1 to 25, further comprising switch means for changing a directivity characteristic of the antenna apparatus by selectively switching over the plurality of antenna elements.

29. The antenna apparatus as claimed in Claim 28,

wherein the control means detects signal levels of the radio signals received by the plurality of antenna elements, and controls the switch means so that the antenna element that receives the radio signal having the maximum signal level is selected.

30. The antenna apparatus as claimed in any one of Claims 1 to 25, further comprising:

a plurality of adjuster circuits for adjusting signal levels of the radio

signals received by the plurality of antenna elements;

a plurality of phase shifters for adjusting phase shift amounts of output signals from the respective adjuster circuits; and

a signal combiner for combining the output signals from the respective phase shifters, and outputting a combined signal.

31. The antenna apparatus as claimed in Claim 30,

wherein the control means calculates such signal level adjustment amounts in the respective adjuster circuits and phase shift amounts in the respective phase shifters that a signal level of the output signal from the signal combiner is maximized, and controls the plurality of adjuster circuits and the plurality of phase shifters based on calculated signal level adjustment amounts and phase shift amounts.

32. A waveguide array antenna apparatus comprising a plurality of waveguide antenna units provided on a ground conductor, each of the waveguide antenna units including a rectangular waveguide and an antenna element,

wherein each of the rectangular waveguides comprises the ground conductor, a ceiling conductor facing the ground conductor, and two side conductors that connect the ground conductor with the ceiling conductor and face each other, and has one end short-circuited by a terminating conductor and an open end, the open ends of the respective rectangular waveguides are arranged on corresponding sides of a polygon on the ground conductor having sides of the same number as that of the rectangular waveguides, and the rectangular waveguides extend outward from the corresponding sides of the polygon on the ground conductor,

wherein one ends of the respective antenna elements are electrically connected to the ceiling conductors in vicinity of the open ends of the respective rectangular waveguides, and another ends thereof are electrically connected to each of a plurality of feeding points arranged on the ground

conductor, and

wherein the waveguide antenna units respectively transmit and receive the radio signal using a predetermined directivity characteristic at the open ends of the rectangular waveguides constituting the waveguide antenna units.

33. The waveguide array antenna apparatus as claimed in Claim 32,

wherein the plurality of waveguide antenna units has the same structure as each other, the open ends of the respective rectangular waveguides are arranged on corresponding sides of a regular polygon on the ground conductor having sides of the same number as that of the rectangular waveguides, and the respective rectangular waveguides extend outward from the corresponding sides of the regular polygon on the ground conductor.

34. A waveguide array antenna apparatus comprising a plurality of waveguide antenna units provided on a ground conductor, each of the waveguide antenna units including a rectangular waveguide and an antenna element,

wherein each of the rectangular waveguides comprises the ground conductor, a ceiling conductor facing the ground conductor, and two side conductors that connect the ground conductor with the ceiling conductor and face each other, and has one end short-circuited by a terminating conductor and an open end, the open ends of the respective rectangular waveguides are arranged on corresponding sides of a polygon on the ground conductor having sides of the same number as that of the rectangular waveguides, the rectangular waveguides extend outward from the corresponding sides of the polygon on the ground conductor, and at least one of the rectangular waveguides comprises at least one slot formed in the ceiling conductor in a width direction of the rectangular waveguide,

wherein one ends of the respective antenna elements are electrically

connected to the ceiling conductors in vicinity of the open ends of the respective rectangular waveguides, and another ends thereof are electrically connected to each of a plurality of feeding points arranged on the ground conductor, and

wherein the waveguide antenna units respectively transmit and receive the radio signal using a predetermined directivity characteristic at the open ends of the rectangular waveguides constituting the waveguide antenna units.

35. The waveguide array antenna apparatus as claimed in Claim 34,

wherein the waveguide array antenna apparatus comprises slots of the same number as an integral multiple of number of the feeding points, slots are provided in the ceiling conductors constituting the waveguide antenna units of the same number as that of the feeding points, the numbers of the slots provided on the respective ceiling conductor are equal to each other, the plurality of the waveguide antenna units has the same structure as each other, the open ends of the rectangular waveguides are arranged on corresponding sides of a regular polygon on the ground conductor having sides of the same number as that of the rectangular waveguides, and the respective rectangular waveguides extend outward from the corresponding sides of the regular polygon on the ground conductor.

36. The waveguide array antenna apparatus as claimed in Claim 34 or 35,

wherein the slots are respectively formed at positions between connecting points with the antenna elements of the ceiling conductors, and the terminating conductors.

37. The waveguide array antenna apparatus as claimed in any one of Claims 32 to 36,

wherein at least one part of an internal space in each of the rectangular waveguides is filled with a dielectric material.

38. The waveguide array antenna apparatus as claimed in Claim 37,

wherein the ground conductor is made of an electrical conductor pattern formed on a first surface of a dielectric substrate having first and second surfaces opposing to each other,

wherein the ceiling conductors are each made of an electrical conductor pattern formed on the second surface of the dielectric substrate, and

wherein the side conductors and the terminating conductors are respectively formed by a plurality of through-hole conductors formed by filling through holes formed in the dielectric substrate in a thickness direction thereof with a conductor.

39. A waveguide array antenna apparatus comprising a plurality of waveguide antenna units provided on a ground conductor, each of the waveguide antenna units including a rectangular waveguide and an antenna element,

wherein, each of the rectangular waveguides comprises the ground conductor, a ceiling conductor facing the ground conductor, and two partitioning-wall conductors that connect the ground conductor with the ceiling conductor and face each other, the rectangular waveguides are arranged in such manner that the partitioning-wall conductors are respectively shared between the two rectangular waveguides adjacent to each other, each of the rectangular waveguides has one end short-circuited by a terminating conductor and an open end, the open ends of the respective rectangular waveguides are arranged on corresponding sides of a polygon on the ground conductor having sides of the same number as that of the rectangular waveguides, and the rectangular waveguides extend outward from the corresponding sides of the polygon on the ground conductor,

wherein one ends of the respective antenna elements are electrically connected to the ceiling conductors in vicinity of the open ends of the

respective rectangular waveguides, and another ends thereof are electrically connected to each of a plurality of feeding points arranged on the ground conductor, and

wherein the waveguide antenna units respectively transmit and receive the radio signal using a predetermined directivity characteristic at the open ends of the rectangular waveguides constituting the waveguide antenna units.

40. The waveguide array antenna apparatus as claimed in Claim 39,

wherein the plurality of waveguide antenna units has the same structure as each other, the open ends of the respective rectangular waveguides are arranged on corresponding sides of a regular polygon on the ground conductor having sides of the same number as that of the rectangular waveguides, and the respective rectangular waveguides extend outward from the corresponding sides of the regular polygon on the ground conductor.

41. A waveguide array antenna apparatus comprising a plurality of waveguide antenna units provided on a ground conductor, each of the waveguide antenna units including a rectangular waveguide and an antenna element,

wherein each of the rectangular waveguides comprises the ground conductor, a ceiling conductor facing the ground conductor, and two partitioning-wall conductors that connect the ground conductor with the ceiling conductor and face each other, the rectangular waveguides are arranged in such manner that the partitioning-wall conductors are respectively shared between the two rectangular waveguides adjacent to each other, each of the rectangular waveguides has one end short-circuited by a terminating conductor and an open end, the open ends of the respective rectangular waveguides are arranged on corresponding sides of a polygon on the ground conductor having sides of the same number as that of the

rectangular waveguides, the rectangular waveguides extend outward from the corresponding sides of the polygon on the ground conductor, and at least one of the rectangular waveguides comprises at least one slot formed in the ceiling conductor in a width direction of the rectangular waveguide,

wherein one ends of the respective antenna elements are electrically connected to the ceiling conductors in vicinity of the open ends of the respective rectangular waveguides, and another ends thereof are electrically connected to each of a plurality of feeding points arranged on the ground conductor, and

wherein the waveguide antenna units respectively transmit and receive the radio signal using a predetermined directivity characteristic at the open ends of the rectangular waveguides constituting the waveguide antenna units.

42. The waveguide array antenna apparatus as claimed in Claim 41,

wherein the waveguide array antenna apparatus comprises slots of the same number as an integral multiple of number of the feeding points, slots are provided in the ceiling conductors constituting the waveguide antenna units of the same number as that of the feeding points, the numbers of the slots provided on the respective ceiling conductors are equal to each other, the plurality of the waveguide antenna units has the same structure each other, the open ends of the rectangular waveguides are arranged on corresponding sides of a regular polygon on the ground conductor having sides of the same number as that of the rectangular waveguides, and the respective rectangular waveguides extend outward from the corresponding sides of the regular polygon on the ground conductor.

43. The waveguide array antenna apparatus as claimed in Claim 41 or 42,

wherein the slots are respectively formed at positions between connecting points with the antenna elements of the ceiling conductors, and

the terminating conductors.

44. The waveguide array antenna apparatus as claimed in any one of Claims 39 to 43,

wherein at least one part of an internal space in each of the rectangular waveguides is filled with a dielectric material.

45. The waveguide array antenna apparatus as claimed in Claim 44,

wherein the ground conductor is made of an electrical conductor pattern formed on a first surface of a dielectric substrate having first and second surfaces opposing to each other,

wherein the respective ceiling conductors are made of an electrical conductor pattern formed on the second surface of the dielectric substrate, and

wherein the partitioning-wall conductors and the terminating conductors are respectively formed by a plurality of through-hole conductors formed by filling through holes formed in the dielectric substrate in a thickness direction thereof with a conductor.

46. The waveguide array antenna apparatus as claimed in any one of Claims 32 to 45, further comprising a matching conductor connected between each of the ceiling conductors and the ground conductor in vicinity of the antenna elements in the antenna units, the matching conductor adjusting input impedances of the respective antenna elements.

47. The waveguide array antenna apparatus as claimed in any one of Claims 32 to 45, further comprising at least one matching conductor electrically connected to the ground conductor, the matching conductor adjusting an input impedance of the antenna apparatus.

48. The waveguide array antenna apparatus as claimed in Claim 47,

wherein at least one of the antenna elements is electrically connected to at least one of the matching conductors.

49. The waveguide array antenna apparatus as claimed in Claim 47,

wherein at least one of the ceiling conductors is electrically connected to at least one of the matching conductors.

50. The waveguide array antenna apparatus as claimed in any one of Claims 32 to 49, further comprising at least one directivity characteristic controlling conductor electrically connected to the ground conductor, the directivity characteristic controlling conductor changing a directivity characteristic of the antenna apparatus.

51. The waveguide array antenna apparatus as claimed in Claim 50,

wherein the directivity characteristic controlling conductor comprises:

a first electrical conductor part electrically connected to the ground conductor and provided to be substantially vertical to the ground conductor, the first electrical conductor part controlling a directivity characteristic on a plane substantially vertical to the ground conductor; and

a second electrical conductor part connected to the first electrical conductor part and provided to be substantially in parallel to the ground conductor, the second electrical conductor part controlling a directivity characteristic on a plane substantially in parallel to the ground conductor.

52. The waveguide array antenna apparatus as claimed in Claim 51,

wherein the second electrical conductor part of the directivity characteristic controlling conductor is connected to the first electrical conductor part of the directivity characteristic controlling conductor at a central part in a longitudinal direction of the second electrical conductor part, and

wherein a sum of a length of the first electrical conductor part and half a length of the second electrical conductor part is a length substantially a quarter of a wavelength corresponding to a resonance frequency of the waveguide antenna unit whose directivity characteristic is controlled by the directivity characteristic controlling conductor.

53. A radio communication apparatus comprising:

any one of the antenna apparatuses claimed in Claims 1 to 31, and

a radio communication apparatus circuit,

wherein the radio communication apparatus comprises:

a radio transmitter circuit connected to the antenna apparatus, the radio transmitter circuit generating a radio signal and transmitting a generated radio signal via the antenna apparatus; and

a radio receiver circuit connected to the antenna apparatus, the radio receiver circuit receiving a radio signal via the antenna apparatus.

54. A radio communication apparatus comprising:

any one of the antenna apparatuses claimed in Claims 32 to 52; and

a radio communication apparatus circuit,

wherein the radio communication apparatus comprises:

a radio transmitter circuit connected to the antenna apparatus, the radio transmitter circuit generating a radio signal and transmitting a generated radio signal via the antenna apparatus; and

a radio receiver circuit connected to the antenna apparatus, the radio receiver circuit receiving a radio signal via the antenna apparatus.